Restoring Lake Herrick
Information for Improved Water Quality and Enhanced Recreational Value

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I. Introduction
Lake Allyn M. Herrick is a 15-acre water body on the southern end of the University of Georgia’s campus, located in the center of the Intramural Field and Oconee Forest Park complex. Its watershed encompasses 248 acres, including 66.4 acres which drain into the subwatershed of a nearby pond. Land uses within the watershed include the entirety of UGA’s intramural fields and Oconee Forest Park, as well as a portion of a residential neighborhood.

The lake was constructed in 1982 for purposes of recreation, research, and teaching. It originally featured a beach with a swimming area, a boathouse with canoes and sailboats available for student use, and a management plan that provided for fishing. It was also the site of an annual triathlon. However, swimming and boating were banned in 2002 following a period of declining water quality and various management problems. The lake managers also stopped stocking the water with fish. Since then, the lake has remained closed and persists in an underutilized state, although Lake Herrick and the Oconee Forest Park continue to be used by many classes for field studies in forestry, ecology, biology, and other biological sciences.

There is growing support for remediation of Lake Herrick’s water quality, both out of recognition of its ecological value and for the opportunity to restore its once popular recreational uses. This report explores various issues related to the feasibility of restoration activities at Lake Herrick, beginning with an overview of the lake’s history as evidenced by a review of management documents. This leads to an inventory of water quality conditions, informed by data collected regularly on various parameters beginning in 2006. Next is a series of case studies which reviews other southeastern universities with lakes and rivers on campus and how those areas are financed and maintained for recreational purposes. This is followed by a report on a survey which was conducted to gauge UGA students’ perceptions about Lake Herrick. Additional sections present opportunities for outreach and community engagement regarding water quality issues, a plan for an expanded water quality monitoring program to measure the water’s suitability for swimming, and a review of the liability implications of operating an aquatic recreation facility.

II. Prehistory, Establishment, and Evolution
IIA. Before Lake Herrick
nursery. During this time, the area provided informal housing for UGA students, who occupied the Forestry Club cabin, the CCC building, the nursery building, and several shacks in the woods.

A fire tower was built on the high point to the south of the Forestry Club cabin in 1953. This area, referred to as Fire Tower Hill, is adjacent to the current location of the Athens Perimeter. Sometime in the 1950’s, a spring-fed pond was created to the south of Lake Herrick’s current location. By the late 1950’s, the Forestry Club cabin had fallen into a state of disrepair and was demolished. A picnic shelter was erected in its place and remained for about twenty years; it was dismantled in 1980. In the early 1960’s the Board of Regents swapped a portion of Oconee-Denmark Forest (mostly from the original Denmark Farm tract) for the land which is now the University Golf Course. The nursery was relocated to Whitehall Forest in 1968.
Following the relocation of the nursery, the land where Lake Herrick would eventually be constructed was kept mostly clear of trees and may have been used as pasture in association with the nearby horse barn.

In 1975, the Georgia Department of Transportation (DoT) built Highway 10 - the bypass which forms a perimeter loop around Athens. This resulted in the removal of the fire tower and the fragmentation of Oconee-Denmark Forest. During construction, the DoT installed two 30-inch diameter culvert pipes to convey water under the bypass into the Lake Herrick watershed. The bypass runs along a high point which was the boundary for Lake Herrick’s watershed. Thus, the culverts represent an interbasin transfer. (Dan Williams interview September 26, 2013) At this time, the forest was frequently utilized as an outdoor laboratory for teaching field methods in forest engineering classes. It was also popular with botany and dendrology instructors, who were attracted by its rich flora. Recreational hiking was not uncommon and people used the forest roads for running. Horseback riding was perhaps the most popular recreational activity, but by the early 1980’s, the horse pastures which had existed in the area were being converted to lake bottom and the intramural fields. Motorcycles were noted as nuisance, having run a trail up the area’s steepest slope which was richest in wildflowers. The source document is not clear about the location of this slope, but it may have been referring to the still-operational powerline corridor.

II.B. Lake Herrick and Oconee Forest Park: 1982 to 2005

Oconee Forest Park was established in 1982 as a 117-acre tract (the remainder of UGA’s Oconee-Denmark Forest property) which was owned by the College of Agriculture but utilized extensively by the School of Forest Resources. That April, Dan Williams officially became the Oconee Forest Park’s first employee. Through the School of Forest Resources, he occupied the position of park manager until his retirement in 2014. The official boundary of Oconee Forest Park was divided into two pieces by Highway 10. The 45-acre western tract still exists in its entirety. The Oconee Forest Park Revised Master Plan for Development, drafted by former forestry professor Walter Cook, describes the area as bounded by Lake Herrick to the north, by a horse barn located on the “eastern slope of the area north of the park,” by the Southern Railway to the west, by the Athens Perimeter Highway to the east, and by an open, triangular patch of land with a pond to the south. This land and pond, now recognized as part of the park, was originally used by the Physical Plant’s Grounds Maintenance Unit for compost and landscape plant storage. Irrigation trucks were filled with water from the pond for watering landscape plants on campus. At the time that the park was established, Physical Plant was phasing out their use of the property (which was only accessible through Oconee Forest) pending its conversion to park land. The eastern tract, originally a narrow strip of about 40 acres (the source document does not account for the additional 32 acres in the 117 which it initially attributes to the forest park – presumably Lake Herrick counts for 15) was bordered by Riverbend East subdivision and the North Oconee River. A committee appointed by UGA’s President Henry Stanford had recommended that the west bank of the North Oconee River corridor be included as part of the
North Oconee River Greenway, but the tract remained undeveloped and there were no specific plans for its development as part of the park, probably because access was cut off by the loop. The School of Forest Resources’ stated goal for the park was to “preserve the remaining pieces of the Oconee-Denmark Forest in a more-or-less natural condition, and provide a forest environment, and facilities for enjoying it, to the campus community.” A description of the forest at this time noted that the vegetation throughout was composed of mixed pine trees and hardwoods of various sizes. The north and northwest slope had particularly large hardwoods and some “old woods pine.” Also noted is the “excellent stand of large white oak” near the base of the northwest slope. Wildflowers and flowering understory trees such as dogwood, redbud, buckeye, serviceberry, and azalea were all common, especially on the north slope.

The park’s designers envisioned “a quiet place to get free from the tensions and pressures caused by academic requirements and the social abnormalities of living in non-family groups.” As such, they specified the following objectives in the Oconee Forest Park Master Plan:

1. “To preserve the Park’s natural character and influence.”
2. “To provide for the enjoyment of activities appropriate to its natural environment.”
3. “To allow use by students and faculty for practice, demonstration, teaching, and research.”

In June of 1982, construction of the dam for Lake Herrick was finished. Aerial photos indicate that the land which was flooded to create the lake was mostly clear of trees as early as 1938, with the exception of a narrow vegetated buffer along the stream which ran through the site. During construction, those remaining trees were removed and the lake bed was thoroughly cleared of stumps. Before the dam was closed, the lake bed was treated with 32 tons (1.5 tons/acre) of lime. Both tributary streams and the small pond in Oconee Forest Park were treated with Rotenone to eliminate undesirable “trash” fish. The reservoir was dedicated the following month. It had a surface area of 15 acres, a volume of about 150 acre feet, a maximum depth of 24 feet near the dam, and an average depth of about 9 feet. Two fishing piers were built in short order, along with a road over the dam to provide access to them. The service road which runs south from the tennis courts to Parvo Pond, parallel to the railroad tracks, was constructed in September of that year. In October, the lake was stocked with 800 bream (Lepomis macrochirus), 800 red-ear sunfish (Lepomis microlophus), and 800 channel catfish. 800 large-mouth bass were introduced the following May. The bream and red-ear sunfish are closely related species, and no distinction is made between them in subsequent management documents.

In 1984, the School of Forest Resources constructed a boathouse to store ten canoes (which were purchased by the Recreational Sports Department sometime before 1987; Rec

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1 Parvo Pond is a colloquial name for the small pond within Oconee Forest Park which feeds into Lake Herrick via a tributary stream. The date of the pond’s construction is not clear, but it existed before Oconee Forest Park was established. When referenced in documents from the 1980’s, the pond is referred to by its location rather than a proper name. Sometime in the last thirty years, the water body picked up its informal and pejorative nickname which refers to canine parvovirus - a highly contagious disease which is spread between dogs via contact with their feces.
Sports continued to store them in the boathouse) and six small sailboats. The structure also included workspace and tool storage. During the winter of 1984 and ’85, the instructor of a Forest Recreation class gave students the choice of writing a term paper or building trails. Consequently, students built over a mile of trails. The original purpose of these trials was to provide an outlet for “cerebral recreation and quiet contemplation.” The park planners’ vision was further explained as “an opportunity for a low-key, unhurried, tranquil, and enjoyable encounter with an attractive, natural environment.” The trails quickly became very popular, and mainly for a previously unanticipated activity: jogging. Park managers realized that much of the park’s popularity was due to the opportunities for active recreation created by the trails, rather than the inherent naturalness of the forest. This point may have caused a slight shift in park administrators’ vision for the area, but it did not conflict with the overall mission of preserving the forest environment for the enjoyment of the University community.¹⁶

One problem which was beginning to manifest at this point was the issue of sanitation, as the park did not have restroom facilities. Plans were drawn for a 16’x24’ restroom to be located near the picnic area. However, construction was put on hold pending the provision of electricity and a water source. Various plans which were considered to supply the park with water included running a line across (either above or under) the lake or to build a well with a storage tank. The plan was to provide electricity and water to the existing boathouse and picnic area structures, as well as the proposed restroom (and a drinking fountain in front of it), shelterhouse, multi-purpose facility, and manager’s residence. Park administrators postponed the construction of new structures and trails and stopped actively promoting visitation to the park, recognizing that current use was already at or above capacity until proper restrooms could be built.¹⁷ Electricity and water were extended to the boathouse and picnic pavilion in 1994. Restrooms were built at the intramural fields and across the footbridge near the tennis courts. The proposed multi-purpose facility and manager’s residence have not been built.

Between mid-summer 1983 and winter of 1985, a serious erosion problem developed. Physical Plant attempted to grade the service road in the 1300-foot powerline corridor which parallels the bypass in Oconee Forest Park. This quickly resulted in the formation of a deep gully, and the eroded soil washed into Lake Herrick. Over a couple of months, about 5000 cubic feet of sediment formed a delta which was estimated to be 50 feet long, 20 feet wide, and 5 feet deep. By fall of 1984, the erosion had begun to slow down as it worked its way into deeper, firmer soil. That winter Physical Plant attempted to re-grade the road, resulting in the depletion of the remaining ground cover vegetation and the renewal of the erosion, which had by then progressed to critical levels. The School of Forest Resources developed and implemented a plan to halt the erosion by constructing a series of box culverts and covering the slope with a layer of straw mulch, pending grass seeding in the spring.¹⁸

Having allowed nearly two years for the stocked fish populations to grow, the lake was opened for fishing in March 1985. Established limits were 5 bass per person per day, 5 catfish per person per day, and 50 bream per person per day. The minimum size for bass was 14 inches, and there was no minimum size for catfish or bream. Soon thereafter, in May, an annual
fertilization regimen was implemented; park staff applied liquid fertilizer (10-30-0 formula) at one gallon per surface acre during the growing season. During this first season, samples derived from electro-fishing indicated a growing population with a balanced ratio of bass to bream.\(^{19}\)

In 1985, following a year of fishing, samples indicated smaller fish sizes overall and increasing bream relative to bass. Filamentous algae were also detected in the lake in 1985 and 1986; park management determined that the appropriate treatment was to apply copper sulfate crystals to the lake – 200 pounds the first year and 35 pounds the next.\(^{20}\)

By 1986, it was apparent that chemical treatment of the intramural fields, described in one document as fertilization and liming but probably not limited to just those two treatment methods, could be suppressing the growth of phytoplankton in the lake. Phytoplankton are essential to the lake’s ecology because they are the base of the food chain for the lake’s fish populations. The stated management objective at this time with regards to fishing was to “provide better fishing without impeding swimming,” so a healthy phytoplankton population would be essential to accomplish this. A consultant who was commissioned to provide management recommendations advised applying more lime to the lake over the winter at a rate of ½ ton per acre, as well as to apply liquid fertilizer (10-30-0 at a rate of one gallon/acre) every 2-3 weeks while the water temperature was above 65 degrees Fahrenheit. Although the recommended frequency of application was notably high, the treatment was anticipated to provide phytoplankton with enough nutrients to overcome suppression by herbicide inputs and produce an 18” bloom which would block out light and kill submerged algae (which had apparently not been sufficiently suppressed by the tons of copper sulfate crystals which were dumped into the lake previously). Theoretically, this would be most effective in the deeper parts of the lake; algae is more difficult to suppress in shallow water. This fertilizer treatment would be followed up with copper sulfate spot treatments in areas which continued to exhibit algae problems. The extent to which this advice was implemented is not clear – a handwritten note on the document expresses concern about the expense of a second lime application. In any case, the consultant noted that the fish population was on a desirable trajectory and predicted that good fishing would be attainable if high-phosphorous fertilizer applications continued.\(^{21}\)

In July 1986, the water turned a chalky green and gave off a putrid, rotting odor. White, slimy strands were observed floating in the water. Cooperative Extension Service fisheries experts George Lewis and Ronnie Gilbert explained that high winds were causing organic matter to be stirred up from the bottom of the lake, resulting in a fungal bloom. The water cleared on its own after a week. \(^{1986}\) also marks the beginning of annual fecal coliform testing performed by UGA’s Environmental Safety Service.\(^{22}\) There is no indication of how many years these tests were conducted. In the nearly three decades since those tests were initiated, the Environmental Safety Service (now known as the Environmental Safety Division) has moved offices, experienced significant staff turnover, and even changed their organizational goals and the services which they offer. Any records of the tests have been lost and the people who had been in charge of administering the testing are no longer available for contact. (Phone conversation with Bill Favaloro, Environmental Safety Division. March 25, 2014)
Also in 1986, efforts to encourage Canada geese to nest at the lake were successful. Of two pairs received in July 1986, one pair had nested and reared three young during their first season at the lake. The flock had grown to seven geese and could fly, but instead chose to remain and make Lake Herrick their permanent home. In the summer of 1987, a flock of about twenty geese flew in and took up residence. The birds preferred to rest around the beach. Initially they were a popular attraction with the swimmers, who fed and watched them, but their feces quickly degraded the sand at the beach to the point of being disgusting and unsanitary.23

Recreational Sports Director Jane Russell complained that the beach was losing significant revenue, so a plan to discourage the geese from using the beach was implemented. Droppings were manually removed, signs were posted prohibiting feeding the geese, and the lifeguards were trained to fire a gun loaded with harmless “screamer bullets” to scare the geese away. A wildlife damage control expert who was consulted suggested building a new, separate habitat area for the geese to divert them from the beach. The area would be located to the west of the beach between the two inlet bays – 20 tons of sand would be spread over an area large enough to accommodate the bird population.24

The habitat area was built and, predictably, the geese used that area and the beach. Over the next two decades, flocks of 20-40 geese congregated on the beach at Lake Herrick on a regular basis25 and were attributed to at least three separate beach closures due to excess fecal coliform pollution.26 They are part of a local population that lives in Athens year round and moves between several local locations.26

Historically, Oconee-Denmark Forest (and Oconee Forest Park, in its early years) was a popular location for horseback riding; the nearby horse barn had provided easy access to the forest. By the time the Oconee Forest Park Revised Master Plan for Development was published in 1987, most of the barn’s former pasture land was under water and management had banned horses on park trails. Recreational riding was confined to a single riding ring which, along with the barn, would soon be cleared and replaced by sports fields. Around this time, mountain bikes were noted as a “menace” on the trails. The Revised Master Plan for Development cites the need for “sustained and determined efforts” to rid the park of bikes, like the ones which were taken to drive out the horses. Currently, bikers still ride some of the trails throughout the park but access to many trails is restricted by signage and gates. Unauthorized swimming from the fishing piers has also been a problem.28 There has most likely been a sharp reduction in the number of swimming violations in the years since the swimming ban was implemented, as public perception of the cleanliness of the water has changed. However, there are still instances of people swimming off of the piers (Anecdote from anonymous student), probably out of ignorance due to the lack of posted rules and water quality information.

Research activities were notably limited during the first years of the park, but were still predicted to be the most valuable future use. No specific reason was given as to why research would be more valuable than recreation or teaching. The park was experiencing extensive educational use by classes, labs, recreation interns and practicums. Day camps and interpretive
programs for children and adults had also been offered. This was expected to be more frequent when running water and bathrooms became available.29

Other plans for expansion which were noted in the Revised Master Plan for Development include the footbridge which crosses the cove on the south end of the lake and a few additional trails, which have since been built. A couple of facilities which were planned for construction have not been built. These include a manager’s residence, for a full-time, live in manager, and a multi-purpose facility. The multi-purpose facility would include space for group picnics (which had proved to be a surprisingly popular activity), day camping for kids, departmental meetings, and informal parties. The space was to be accompanied by an amphitheater, which would have electricity for showing movies and presentations. Both facilities were planned to be located in the southeast corner of the park, the manager’s residence tucked away just north of the multi-purpose facility.30

By 1987, the fish population in the lake was much lower that it had been three years earlier when fishing was originally allowed. Heavy fishing pressure was resulting in a significant depletion of bass and bluegill. Channel catfish were being depleted as well; their population may have been dwindling because they generally do not reproduce well in stocked ponds. It was becoming apparent that, due to the heavy fishing pressure, it would be impossible to maintain good fishing with self-sustaining fish populations alone. The park manager began to subsidize Lake Herrick’s fish population by introducing 2000 young catfish every year for about five years.31

In summer 1989, Lake Herrick management commissioned fishing management recommendations from two different individuals. The advice was solicited with the objective of providing better fishing in light of the problem of too few, skinny bass and an overabundance of small bream. The first consultant interpreted the water quality as “very good” and not in need of change. Populations of bream and bass were both reproducing, but analysis of electrofishing and seine data indicated that the bream were stunted and smaller than they should have been. Very few were growing into the intermediate (3-5 inch) size range, and almost none got any larger than five inches. The report notes that the 2000 four-inch catfish which were introduced annually were probably competing with the bream and bass for food. Fertilization, although it would help the fish grow larger, was not recommended because it would be quickly diluted by water flowing in from tributaries and it would turn the water green (presumably from blooms of algae or phytoplankton), which would be repulsive to swimmers. Ultimately, the consultant recommended decreasing the daily limit on bass from five to two and increasing the limit on bream from 50 to 100. He stated the need for posters to help people distinguish between different kinds of fish.32

The second consultant noted that the lake was “extremely” overcrowded with bream. The ratio of total weight of forage species (catfish and bream) to carnivorous species (largemouth bass) was balanced. However, the total weight of harvestable fish to total weight of fish overall was undesirable, at only 13% (versus the more desirable 40-85%). The author noted that the best way to correct the ratios would be to drain the pond and start over, which she
acknowledged to be impractical. Her recommendation was similar to the first: take advantage of
fishing pressure by stopping all bass fishing and encouraging unlimited bream harvest. This
would be supplemented by seining a fifteen-foot perimeter around the pond and removing all
bream and mosquito fish (a non-game fish species which apparently had established a population
in the lake at some point). The consultant recommended continued fertilization, but liming
would not be necessary as the lake already received sufficient inputs via runoff from the
intramural fields. It was noted that there was no algae problem, but copper sulfate could be used
in the event of one. A handwritten note indicated that management found this plan preferable to
the first one.  

A report published a decade after these fishing management plans were produced
mentions that Lake Herrick was limed, stocked, and fertilized from 1982 to 1989. Fertilization
and liming were discontinued in 1989 and stocking stopped the following year (with the
exception of channel catfish, which were stocked until 1992).  

A 1989 memo drafted by UGA law students outlines several avenues by which pollutants
were known to enter Lake Herrick. The first is runoff from the intramural fields; the
University’s grounds crew sprays fertilizer, herbicide, insecticides, and fungicides on the “upper
bank” of the fields, but rarely on the lower bank which is closer to the lake. A separate
maintenance crew under the direction of the School of Forest Resources used Roundup to control
vegetation around the Parvo Pond, some of which probably also entered the lake. One feeder
stream was noted as conveying water from a pond on the far side of the bypass and probably
received runoff from the bypass. The other feeder stream, which flows through the residential
neighborhood on the other side of East Campus Road, conveys runoff of unknown quality. The
student authors recommended regular monitoring of the lake and its feeder streams, and
suggested that detailed records should be maintained and the information made available to the
general public. They also noted that an estimated 5-6,000 people “use the lake annually,”
although they do not specify the activities which constitute said “use,” nor do they provide a
source for this information. A 1989 survey indicated that Oconee Forest Park receives over
50,000 individual visits per year, in addition to extensive group recreation and teaching use.  

Also in 1989, the aquatic plant Brazilian *elodia* became established in Lake Herrick. The
plant was likely introduced by somebody dumping the contents of their aquarium; *elodia* is a
common aquarium plant because it filters water very effectively. This property had the
remarkable effect of turning the lake’s historically murky water quite clear. (Dan Williams
interview September 26, 2013) The plant quickly spread throughout the lake, forming thick mats
on the bottom to a depth of about twelve feet. This made fishing difficult, was advantageous to
bream (which were already over-abundant), and was a problematic safety and aesthetic concern
during the 1995 Recreational Sports Triathlon. The impediment to the triathlon seems to have
been the last straw; in March 1996, 125 fingerling grass carp were added to the lake. The
previous winter had brought “die-back” conditions, so the carp nearly eradicated the *elodia*
within six months. The carp had haploid genetics and were thus unable to establish a breeding
population in the lake. They are also vegetarians and thus cannot be caught by rod or reel – an
essential trait for survival under heavy fishing pressure. A small amount of *elodia* continues to
grow in the water and around Lake Herrick’s banks, but it has not rebounded to anywhere near
the overgrown conditions which proved to be so problematic. (Dan Williams interview
September 26, 2013)

In the mid-‘90’s, UGA built the Bus Center on Riverbend Road. Construction resulted in
notably high sediment inputs into the Lake Herrick watershed through the 30-inch pipes which
run under Highway 10. The Campus Planning Department was notified of the erosion problem
and made efforts to impound the stormwater and detain and release it more slowly. This
anecdote speaks to a process which has been ongoing since the lake was built: erosion and
sedimentation. Years of erosion have caused sediment to come to rest in and above Parvo Pond,
in the stream between the pond and the lake, in the upper reaches of the cove where the stream
enters the lake, and across the lake bottom itself. Each big storm “re-entraines” the sediment,
washing it further downstream. Over the twelve year period from 1985 to 1997, the maximum
lake depth below the footbridge decreased by six inches. The maximum depth near the dam
was eight meters when the lake was created. Measurements taken in 1999 showed it to be no
deeper than 5.5 meters. This change of nearly 100 inches in 17 years indicates a much higher
rate of sedimentation at the dam than that observed in the cove near the footbridge.

There are two primary sources by which stormwater and sediment enters the lake via
Oconee Forest Park (this description does not include inputs from other parts of the watershed -
the intramural fields or East Campus Road and the area to the west of it). Normal runoff from
within the park does not generate significant sediment input because the area is mostly forested.
Roads are kept surfaced with gravel and lined with road dips and culverts for drainage. These
maintenance practices are adequate for normal water and sediment quantities. Trails are
reinforced with water diversion bars, gravel, and wood chips on an as-needed basis. Strong
winter storms can occasionally overwhelm park drainage systems, causing erosion and
sedimentation, so regular spring maintenance is conducted to address winter impacts.

Most sediment in Lake Herrick comes from water diverted into the lake and its tributaries
from outside the forest park. There are three main sources – two of them are the aforementioned
culvert pipes which convey water (and probably other undesirable runoff) from the Bus Center.
The third source of sedimentation has its origins within the Oconee Forest Park: the degradation
of trails by excessive numbers of mountain bikes, and visitors with pets who often and
consistently do not heed leash rules. Yearly maintenance to remediate these impacts is
significant in terms of time and money.

In 1997, after more than a decade of fishing, a well-balanced and large bass population
remained elusive. The problem of managing for higher quality fish in the face of heavy fishing
pressure was still pertinent; students produced another management plan. Bass and bream were
specified as the two desirable sport fishing species; stocking of channel catfish had been
discontinued five years previously. Both desirable fish populations were reproducing, but there
were very few intermediate sized bream because of competition with crappie and heavy
predation pressure from largemouth bass, crappie, and gar. The bass were not reaching their
desired plumpness either, primarily because they did not have a sufficient food base (bream) on account of competition from crappie and gar.\textsuperscript{42} It is not clear why crappie were not regarded as desirable for recreational fishing, as they are generally popular amongst anglers. Their origin in Lake Herrick is undocumented – perhaps they were introduced in the previous five years as a substitute for the discontinued channel catfish. The gar are also of mysterious origin. This plan was the first mention of their presence in the lake. They were not likely to have been introduced intentionally by the lake manager, but they have been known to travel from rivers through sewers and culverts to reach lakes and ponds.\textsuperscript{43}

The students noted that fertilization was not being conducted regularly. They recommended a fertilization program to increase the lake’s productivity, as fertilization would result in phytoplankton blooms, which would shade out weedy aquatic vegetation and provide food for fish. They caution that, once initiated, fertilization must be done on a regular basis. Irregular fertilization can result in oxygen depletion and cause a fish kill. They observed that aquatic vegetation was present in the lake and noted that it could cause problems in the future if left unmanaged. They concluded with the recommendation that, since increased fishing is not the objective, management activities should focus on regulating fishermen rather than the fish population. This could be accomplished with more signs about rules for size and catch limits.\textsuperscript{44}

In July 2002, following a solicitation by Oconee Forest Park management to investigate an odd change in color, UGA hydrology professor Dr. Todd Rasmussen reported that the lake water was a “brownish olive color.” He speculated that it probably had to do with urban stormwater entering the lake from recent storms, primarily via the western tributary. A heavy dose of urban stormwater could contain pesticides, herbicides, sediments, pathogens, metals, nutrients, and other assorted pollutants. He suggested that, without further input, the lake would return to its regular color soon.\textsuperscript{45} This manifestation of pollution in the water at Lake Herrick spurred conversation. One correspondence between UGA staff members in the Environmental Safety Division and the Recreational Sports Department attributed declining water quality to urban runoff and domestic and wild animal populations. The author, Environmental Safety Division employee Renee Perro, suggested water quality testing, previously limited to fecal coliform tests during the swim season, should be more frequent and comprehensive. Conditions had become degraded to the point that testing under the guidance of a hydrologist or other specialist would probably be necessary to judge the suitability of the lake for swimming.\textsuperscript{46}

Two weeks after the initial email about Lake Herrick’s strange coloration, the water had not reverted to its normal color. Instead, a “suspended substance” was observed to be clouding the water. Biology professor Marshall Darley stated that he had taken a plankton sample from the footbridge five to six weeks previously and observed an abnormally high number of cyanobacterial colonies. He thought that they belonged to the genera Microcystis, which is known to produce toxins. Whatever it was, it had been appearing in samples for at least a year, but never as abundantly as he had observed it in June. He made reference to a book which states that 50-70\% of cyanobacterial blooms are toxic, and it would be unwise for any animal to consume water which appears to be affected by such a bloom.\textsuperscript{47}
Dr. Darley returned to the lake and took a sample with a net. A single sweep near the surface clogged the net, which had never happened previously. He was almost completely certain that the mysterious substance was a cyanobacterium (blue-green algae), and believed it to be of the genus Microcystis, which commonly forms blooms. The genus is known to be toxic to animals which consume water in which they are present. The best known toxins produced by cyanobacteria are hepatotoxins and neurotoxins, which do not cause problems unless ingested. Additionally, “lipopolysaccharide endotoxins produced by some Microcystis strains have been implicated in cases of fever and inflammation in humans who have bathed or showered in water that contains cyanobacterial blooms.” Dr. Darley suggested that swimming and wading would not be advisable, but limited hand contact is probably safe. He had personally exposed his bare hands to the lake water for over thirty minutes while conducting tests and experienced no adverse effects. He suggested that it would still be safe to hold canoeing classes, but it would be prudent to have some clean water available to wash hands when engaged in activities which could result in contact with the water. He also mentioned that the resident turtles, fish, and ducks did not seem to be affected, which was a positive sign.

By late August, roughly a month after the cyanobacterial bloom had peaked, the Microcystis was subsiding. However, this episode marked the beginning of an annual cycle. A 2005 correspondence confirms that nutrient concentrations in the lake, especially phosphorus, were consistently causing blue/green algae blooms each growing season. This was exacerbated by hot and “calm” weather, and dry spells followed by sudden heavy rain which carried with it proportionally heavy pollutant runoff inputs.

Also in 2005, Warnell School of Forestry employees made an effort to improve conditions at Parvo Pond. The pond had been subject to overuse at the off-leash dog area, and was a possible source of contamination. It used to overflow frequently and spill over the forest road into the lake. The plan was to rehabilitate the pond, although it is not clear what this was to specifically entail. The dam was breached but had to be patched immediately due to regulatory issues. No rehabilitation work was completed, and the pond has been left basically unmanaged since then. It is smaller than it used to be, drawn down from its original two acres out of concern for the stability of the dam. Heavy winter rains often result in the pond’s outlet pipe getting clogged, so it must be unclogged manually each year. (Dan Williams interview 9-26-2013) The pond is also surrounded by silt fencing – this may have been installed in conjunction with plans for rehabilitation activities and simply never removed. It was most likely placed intentionally either as a long-term preventative measure against sediment input to the pond, or to keep keep dogs out of the water.

The beach at Lake Herrick was closed and swimming prohibited, either in 2002 or 2005. Official documentation of this event has proved elusive, but it can be inferred that the decision to close the beach was influenced by the variety of water quality issues which had been developing. Sailing, canoeing, and kayaking classes were discontinued and recreational boating prohibited as well, out of concern for the possibility of somebody accidentally falling into the lake and falling
ill as a result of bacterial exposure. Since 2005, written documentation of management activities, observations, and problems is lacking.

III. Water Quality Data

III. A. Data from various sources: 1986-1999

Water quality data prior to 2006 is sporadic. Samples are rarely replicated consistently, so what little information exists is patched together from different sources using different methods. A 1986 report recorded the lake’s pH at 8.5-9 and the dissolved oxygen (DO) at 9.5 milligrams per liter (mg/L).\(^5\)1 A separate document reports a 1986 dissolved oxygen sampling value of 4 mg/L.\(^5\)2 In 1988, samples analyzed by the UGA Cooperative Extension Service detected trace amounts of herbicide, but they were below levels which could be accurately measured. The samples were taken at various locations in a single day. However, a handwritten note at the top of the report indicates that the same results were given for 13 additional samples.\(^5\)3 In 1989, a document reported the average pH and DO values from 2 sampling events (separated by a week) as 7.5 and 9.7, respectively.\(^5\)4 In 1997, the pH was recorded as 6.0 and DO as 9.2 in a single, unreplicated sampling event.\(^5\)5

In 1999, 4 students in a graduate level forestry class reviewed water quality conditions at Lake Herrick under the direction of Dr. Todd Rasmussen. In the report, the students surveyed Lake Herrick, Parvo Pond, and the 2 tributary streams at 15 different sampling locations. Samples were taken weekly for 6 weeks.

<table>
<thead>
<tr>
<th></th>
<th>Bridge</th>
<th>Forest Stream</th>
<th>Urban Stream</th>
<th>Lake Outlet</th>
<th>Urban Cove</th>
<th>Dam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO (mg/L)</strong></td>
<td>6.47</td>
<td>6.14</td>
<td>5.95</td>
<td>6.27</td>
<td>7.32</td>
<td>5.18</td>
</tr>
<tr>
<td><strong>Conductivity</strong></td>
<td>43.17</td>
<td>49.67</td>
<td>90.78</td>
<td>53.29</td>
<td>44.50</td>
<td>46.53</td>
</tr>
<tr>
<td>(unknown units)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6.77</td>
<td>6.29</td>
<td>6.27</td>
<td>6.27</td>
<td>6.75</td>
<td>6.55</td>
</tr>
<tr>
<td><strong>Turbidity</strong></td>
<td>11.88</td>
<td>20.31</td>
<td>28.76</td>
<td>8.25</td>
<td>13.23</td>
<td>13.8</td>
</tr>
</tbody>
</table>

Table 1 displays the mean values for select parameters sampled at 6 different monitoring points.

The authors acknowledged concern about bacteria levels, but reported that testing did not show fecal coliform concentrations above 200 colony forming units (cfu) per 100 mL. The highest concentrations of bacteria were found in Parvo Pond and at a monitoring point in the tributary stream adjacent to the tennis courts.\(^5\)6

A series of measurements was taken near the lake’s surface between September 2, 2001 and January 5, 2002. Measurements of alkalinity, CO\(_2\), NO\(_3\), NH\(_4\), PO\(_4\), Secchi depth, and various types of plankton were all recorded. However, the document provides no information regarding sampling location, method, author, or other contextual details.\(^5\)7
Table 2 displays the results of DO and pH samples taken at an unspecified sampling location at Lake Herrick between September 2001 and January 2002.  

III. B. The MS4 Monitoring Program: 2004-present

In 2003, the University of Georgia contracted environmental consulting firm Brown and Caldwell (B+C) to conduct a series of water quality tests on the streams which run through campus. Between November 10, 2003 and September 7, 2004, the firm conducted eight sampling events at nine locations. The purpose of the testing was to evaluate stormwater discharge and generate baseline information in anticipation of receiving a National Pollutant Discharge Elimination System permit. In 2006, B+C resumed water quality monitoring on a regular basis to continue to identify and evaluate water quality issues in stormwater discharged from UGA property. The program has continued and is currently ongoing. B+C conducts a total of eight monitoring events each year; four during dry conditions, and four during wet weather events to gauge the differences between stormwater runoff and base-flow conditions. Sampling locations were established at strategically located stormwater outfalls on UGA campus. Two locations are associated with Lake Herrick. MS4-4b is located at the outflow of the lake, and MS4-4a was located along a tributary to the lake, just downstream of the outflow to Parvo Pond. In October 2007, MS4-4a was discontinued as a sampling location when it became filled in with a beaver dam wetland. It was replaced by MS4-4c, located closer to the Parvo Pond outlet.

B+C samples for stream flow, total suspended solids (TSS), fecal coliform, E.coli, volatile organic compounds (VOCs), total phosphorus, total nitrogen, metals (As, Cu, Pb, and Zn), oil & grease, mercury, pH, dissolved oxygen, temperature, and conductivity. Refer to Appendix C for a series of tables and charts which display average values from each annual monitoring period for select parameters.

Stream Flow (stage)

Stage data provides information on the hydraulic impacts to a stream caused by storm events – the degree to which the flow rate changes during a storm. Stream flow is a product of velocity and volume. Velocity is a strong determinant of a stream’s habitat value, influencing which organisms can live in the water. Volume has implications for water quality; a stream with higher flow has more capacity to dilute and absorb pollutants. Stage also determines the amount of sediment which is conveyed downstream versus settling on the bottom. Fast-moving streams tend to be better aerated and have higher levels of dissolved oxygen.

The 2007 monitoring report found a general pattern amongst all sampling locations of elevated stream flows during spring storm events but no significant difference between dry and wet weather stream flows in the fall. The 2009 monitoring report indicated that stage at MS4-
4b had relatively high variation between wet and dry events, while MS4-4c stayed more consistent, and the 2010 monitoring report found no significant difference between wet and dry sampling for either location. The 2011 report indicated higher average flows at MS4-4b than MS4-4c, but at MS4-4b those fell to lower average dry event stages during the 2012/2013 sampling period.

**Total Suspended Solids (TSS)**

Total suspended solids is a measure of mineral and organic matter in the water column. High levels of sediment can be indicative of erosion and can increase the size of flood zones, accelerate bank erosion, and alter aquatic habitat. Sediment can also serve as a vector for transport of many pollutants, such as nutrients, metals, pesticides, and bacteria. TSS is a gauge of overall biological health; elevated sediment during wet weather indicates erosion in the watershed, which corresponds with decreased biological quality of a water body.

In 2006 TSS levels for MS4-4b, as well as most of the other MS4 sampling locations, were all relatively low. Levels at MS4-4a were nearly double that of many of the other locations, and average measurements for wet weather sampling were four times higher than dry weather sampling. This is indicative of elevated sediment flows from Parvo Pond, especially during storm events. Sampling events in 2007 and 2008 detected relatively unchanged TSS levels for wet events, but a two- to threefold increase for dry events. Sampling in 2009 and 2010 revealed the same general pattern, with MS4-4c exhibiting about twice the levels of suspended sediment as MS4-4b. The relationship between wet and dry averages for MS4-4b was roughly the opposite of that which was detected in sampling from 2007/2008; readings were elevated during wet events and had fallen during dry events. At a glance, these fluctuations are probably within the bounds of natural variation. Statistical analysis could provide more insight into the nature of the data. These patterns, of higher TSS during wet events and dry events and higher TSS at MS4-4c than b, hold true for sampling in 2010 and 2011 as well. During the 2012/2013 sampling period, TSS levels had increased at MS4-4c.

**Bacteria: Fecal Coliform and Escherichia coli**

Fecal coliform is the current state standard metric for health risk associated with bacteria contamination. Coliform bacteria of the family Enterobacteriaceae reside in the digestive systems of humans and warm-blooded animals. They are present in the gut in large numbers and are not pathogenic, but they are accompanied by less abundant pathogenic organisms which are more difficult to monitor directly because of their small numbers. They do not occur naturally in waterways, and their presence thus indicates contamination by human or animal waste.

E.coli is a common pathogenic bacterium which is associated with fecal coliform. Exposure to E. coli can cause digestive and muscular distress, is particularly harmful to children and the elderly, and can even be fatal. In the future, E. coli will most likely replace fecal coliform as the standard metric for bacteria because elevated amounts of fecal coliform have been found even in areas with minimal anthropogenic impact. The Georgia Environmental Protection Division (EPD) is seeking an alternative indicator specifically for human waste and
the potential for human illness. The two are closely related, and their levels in Lake Herrick have displayed similar trends throughout the entire monitoring period.

Georgia EPD classifies the North Oconee River as a drinking water supply and has established the following regulations (Rules and Regulations for Water Quality Control (391-3-6)) for its fecal coliform content:

“For the months of May through October, when water contact recreation activities are expected to occur, fecal coliform is not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from nonhuman sources exceed 200/100 mL (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams. For the months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 mL based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 mL for any sample.”

During the 2006 monitoring period, MS4-4a had a dry event fecal coliform average of 101.43 CFU/mL and a wet average of 268.33 CFU/mL. MS4-4b had a wet average of 36.67 CFU/mL and a dry average of 268.33 CFU/mL which was elevated by a single exceptionally high reading of 1,500 CFU/mL. The rest of the MS4-4b sampling results were in the <20-60 CFU/mL range. For both fecal coliform and E. coli, MS4-4a results were generally three to ten times higher than MS4-4b readings.

During sampling events in 2007 and 2008, average fecal coliform values for dry weather monitoring were about ten times lower than for wet weather events. Both wet and dry measurements at MS4-4c averaged five to ten times higher than MS4-4b. Results from 2009 and 2010 were similar to the 2007/2008 monitoring. MS4-4c values were still generally elevated above the State’s criteria, but they were lower than they had been during the previous period and there was less of a difference between wet and dry events. MS4-4b values generally fell within the range of the State’s criteria, with only one exception in September 2009. Brown and Caldwell reports that during the 2010/2011 monitoring period, fecal coliform averages remained steady and generally unchanged from the previous period at MS4-4b but increased significantly at MS4-4c. Wet weather results had fallen from 2007/2008 but dry weather results remained comparable. MS4-4c levels were lower than 2009 and 2010 sampling during dry weather but were twice as high during wet weather. During the 2012/2013 monitoring period, MS4-4b had no elevated bacteria concentrations but MS4-4c exceeded standards for five out of seven sampling events. Wet event concentrations at MS4-4c were much higher than historical events; dry event concentration was slightly higher. E.coli levels remained consistent with this pattern.
Figure 1 displays fecal coliform data at Lake Herrick and Parvo Pond for the entirety of the MS4 monitoring program as of the writing of this report.

Dissolved Oxygen

Fish and other animals depend on oxygen dissolved in the water column to live. Air and water temperature, stream flow, aeration, atmospheric pressure, sediment levels, respiration, photosynthesis, and decomposition from organisms are all processes and parameters that affect dissolved oxygen levels. Anthropogenic impacts such as leaking sewer lines and inputs of residential yard waste can affect decomposition rates. In environments where decomposition and other factors reduce the availability of dissolved oxygen, there is increased pressure on aquatic organisms. Dissolved oxygen also affects the solubility of certain metals and nutrients. The State of Georgia has established regulations which specify minimum dissolved oxygen levels for state waterways. At least 5.0 mg/L is the mandated average concentration, or 4.0 mg/L for waters that support warm water fish species. Measurements for MS4-4a and b were both generally well over the established limits, but during the wet and dry sampling events in November 2006, the DO measurements for both locations averaged 2.4 mg/L. These low readings do not correlate with low flows (DO is often higher when stream flows are elevated during wet events) and may instead be related to the decomposition of organic materials, which uses oxygen as part of the chemical process. The 2009 Monitoring Report revealed DO levels consistently within the range of 6-11 mg/L – well within compliance of the State’s regulations.

The 2010 monitoring report cites DO as a constituent of concern for MS4-4c; four out of seven samples fell below the State’s criteria for the parameter. Likewise with the 2011 monitoring report, which cites three additional dates in 2010 and 2011 where the parameter fell below the State’s criteria. This happened once at MS4-4b as well, although Lake Herrick outlet conditions usually tend to be consistently well-oxygenated. During the 2012/2013 sampling period, DO was never recorded below the State’s criteria. Low oxygen levels can be attributed to the slow-moving nature of the stream which connects Parvo Pond and Lake Herrick, as well as the presence of high amounts of iron reducing bacteria. Further suppressing streamflow was the recently constructed beaver dam which was present just downstream of the sampling location.
Temperature

Water temperature can vary with climate, season, elevation, groundwater inflow, vegetation, and sun exposure. In heavily urbanized environments, temperature may be affected by increased exposure to solar radiation due to decreased canopy cover. Decreased base flow stemming from increased impervious cover can also result in higher temperatures – groundwater-fed base flow tends to have a stable temperature which buffers against variations in ambient air temperature. Temperature has been consistent at MS4-4 a, b, and c for all monitoring events. It corresponds to seasonal change and ambient air temperature and is not deemed a concern.  

pH

pH measurements in aquatic systems tend to range from 6.0 to 9.0 due to reactions with the atmosphere. Waters with large amounts of decaying vegetation, as might be expected of Parvo Pond and Lake Herrick, tend to have elevated amounts of humic acid which results in decreased pH levels. Acids can also be introduced to aquatic systems via pollutants such as oxides of sulphur and nitrogen, which react with atmospheric water and precipitate as acid rain.

The average pH for both MS4-4a and b for all sampling events in 2006 was very close to 7. During two separate measuring events in October and December, pH for both MS4-4b and c exceeded the State’s criteria of 6 to 8.5. Their values of 9.24 and 10.00 at MS 4-4b and 9.14 and 11.00 at MS4-4c respectively, are briefly noted in the Brown and Caldwell 2009 monitoring report and explained simply as an anomaly. A return to more normal pH values close to 7 for five sampling dates in 2008 support this explanation. The 2010 monitoring report reveals three out of seven pH readings at MS4-4c to be slightly below the State’s criteria of 6. Two of these readings were taken during wet events and one during a dry sampling event. pH at MS4-4b was consistently within the range of 6-7. Sampling in 2010 and 2011 revealed a single event in which pH at MS4-4b was below the State’s criteria. However, low pH readings were found at all sampling locations on this particular day and could be attributed to malfunctioning equipment. Four out of 8 sampling events for this period at MS4-4c were below the State’s criteria. All pH measurements were within the State’s criteria for the 2012/2013 sampling period. Brown and Caldwell notes pH as a constituent of concern for both MS4-4b and c, and suggests several sources which could be influencing the water’s pH: acid rain, decomposing organic matter, or runoff from coal burning or other polluting facilities.

Conductivity

Conductivity is a measure of the water’s ability to conduct an electric current, and can provide insight into the levels of minerals and ionic constituents in the water column. It is a general measurement of water purity and, although it is not inherently linked to human health, it can indicate changes in water quality. For example, a sudden increase in stream conductivity could indicate a new source of dissolved ions in the water. Conductivity does not specifically measure which ions or minerals are present, and it is not influenced by materials which do not ionize in water, such as oil. Conductivity can be influenced by regional geology; streams with
Granitic geological conditions generally do not have naturally high levels of conductivity because granite does not contain minerals which readily dissolve in water. Typical values for conductivity in the Georgia Piedmont range from 0.070 to 0.150 mS/cm.

There was no difference in average conductivity for wet and dry sampling at either location, and values generally fell within the expected range with the exception of a single elevated reading at MS4-4a during a dry monitoring event in August 2006. Between 2008 and 2011, numerous conductivity readings at the Lake Herrick monitoring locations dropped slightly below the typical regional range. However, lower than normal values are not as much a cause for concern as elevated values would be. Conductivity readings at MS4-4b and 4c were slightly higher than historical averages during the 2012/2013 monitoring period — continued increase could indicate a trend of ionic constituents of concern in the watershed.

Turbidity

Turbidity is a measure of water clarity; it is influenced by suspended matter in the water column and is thus an indicator of sediment load and potentially the presence of visible pollutants in a stream. Increases in turbidity may indicate heightened erosion from stream banks, construction, or other sources. Turbidity is a similar metric to Total Suspended Solids, and can affect the chemical, biological, and physical conditions in much the same way as TSS. Turbidity is measured in Nephelometric Turbidity Units (NTUs). The state of Georgia’s policy on turbidity is that “All waters shall be free from turbidity which results in a substantial visual contrast in a water body due to a man-made activity. The upstream appearance of a body of water shall be as observed at a point immediately upstream of a turbidity-causing manmade activity. That upstream appearance shall be compared to a point which is located sufficiently downstream from the activity so as to provide an appropriate mixing zone. For land disturbing activities, proper design, installation, and maintenance of best management practices and compliance with issued permits shall constitute compliance with Paragraph 391-3-6-.03(5)(d).” No definite numbers have been established to serve as guidelines, although the State regulates construction activity, prohibiting downstream increases in turbidity above 25 NTUs compared to levels upstream of the receiving waters.

In 2006, MS4-4a had a dry average of 27.9 NTU and a wet average of 51.8 NTU. MS4-4b had a dry average of 7.6 NTU and a wet average of 56.6 NTU. Turbidity values increased during wet events, and tend to be higher at MS4-4a for dry events but higher at MS4-4b for wet events. Monitoring events in 2007 and 2008 indicated a wet average of 21.44 and a dry average of 10.02 for MS4-4c and a wet average of 633.31 and a dry average of 10.86 for MS4-4b. This significant increase in MS4-4b’s wet average can be attributed to a single elevated reading of 1875 NTU during a sampling event on March 4, 2008. Monitoring in 2009 and 2010 revealed values which were generally consistent with prior data, although the dry average at MS4-4c jumped to 84.30 NTU. Monitoring in 2010 and 2011 revealed values at MS4-4c to be generally somewhat higher than at MS4-4b. During one wet event, MS4-4c’s turbidity jumped to 1,000 NTU. Values were typically lower, ranging between 6.55 and 43.2.
**Volatile Organic Compounds (VOCs)**

The EPA has established guidelines to limit the volatile organic compounds allowed in surface water. VOCs are often flushed into streams during rainfall events and originate from automobiles or other commercial, residential, or industrial sources.

VOCs were sampled four times in 2006 – two wet and two dry – and were not detected in any of the samples. Four sampling events were repeated between 2007 and 2008, 2009 and 2010, and 2010 and 2011 with the same result.

**Oil and Grease (O&G)**

Grease is typically introduced to water bodies through sanitary sewer line leaks, which add household waste in addition to sewer waste. Grease can also indicate improper waste management by food industry sources. Oil inputs generally come from non-point source runoff from roads and parking lots. This is most common in areas with dense transportation infrastructure. Oil can also come from improper handling of waste at automobile maintenance and service centers.

Three MS4 monitoring locations are occasionally sampled for oil and grease because they receive runoff from automobile maintenance facilities. The MS4-4 locations are not included, but perhaps they should be tested for inputs from the UGA bus facility.

**Total Phosphorous**

In natural systems, phosphorous is typically a limiting nutrient which does not occur in abundance. Inputs from agricultural, domestic, and industrial waste and stormwater runoff are common sources of elevated phosphorous in aquatic systems. Fertilizer runoff from lawns and landscaped areas is also common. Most soils in the Georgia Piedmont have the property of immobilizing phosphorous, as it binds readily with clay particles. Thus, phosphorous typically does not enter streams via runoff unless carried with eroded sediment from fertilized areas or when fertilizer is applied directly to the water. When submerged in particularly low dissolved oxygen conditions, phosphorous is released from its chemical bonds with clay, allowing it to mix into the water column.

The EPA’s guideline for acceptable levels of phosphorous is 0.0365 mg/L, and Georgia EPD considers levels above 0.5 mg/L to be high. In 2006, MS4-4a and b were the only two MS4 sampling locations which were below or near the guideline – the other six locations on campus which were tested had elevated phosphorous. Sampling from 2007, 2008, 2009, and 2010 detected somewhat higher levels of phosphorus, with nearly all samples at concentrations higher than the EPA guideline. However, all samples were still well below the EPD’s 0.5 limit. In September of 2011, phosphorous measurements at MS4-4b reached an all-time high of 0.242. Subsequent measurements throughout 2011 were lower, falling near, and often slightly above, the EPA guideline. A single monitoring event in 2011 detected phosphorous at MS4-4c at 1.2 mg/L. Although the other measurements during this period were substantially lower, this raised the dry sampling average above the average for the previous two years. The corresponding level for Lake Herrick during this event was below the method detection limit of 0.0050 mg/L.
During the 2012/2013 monitoring period, total phosphorous levels exceeded the EPD’s limit during one dry MS4-4c sampling event and one wet MS4-4b event. Dry weather values for both sampling points were overall lower than historical values.

Elevated phosphorous levels during wet events are generally attributable to stormwater runoff which carries inputs of dog waste, sewage, and fertilizer from landscaped areas. During dry weather, typical sources of elevated phosphorous are most often related to leaky sewer pipes or septic systems.

**Total Nitrogen**

Total Nitrogen (TN) is a measure of dissolved inorganic and organic nitrogen, as well as particulate forms. Inorganic nitrogen primarily includes nitrate (NO$_3^-$), nitrite (NO$_2^-$), and ammonium (NH$_4^+$). Nitrogen is an essential nutrient for aquatic plants and algae, but it is typically not a limiting constituent. Nitrogen that is bound to organic matter cannot be used by plants or algae. Nitrite reacts readily to organic constituents and is therefore not found in abundance. Ammonium and nitrate are the first- and second-most preferred sources of nitrogen for most aquatic organisms; nitrate tends to be the most abundant form of nitrogen in aquatic systems. Common organic nitrogen sources in aquatic systems include leaves and vegetation, urine, fecal matter, garbage disposal waste, and ammonia-based household cleaners. Ammonia and nitrite can be toxic to fish, but nitrite often reacts with oxygen and converts to nitrate. Ammonium and nitrate are commonly found in commercial fertilizers which can be present in streams via runoff from lawns and landscaped areas.

The EPA’s guideline for acceptable levels of nitrogen is 0.69 mg/L. All values of TN sampled in 2006, with the exception of a single sampling event at MS4-4a, exceeded the suggested value. In many cases they were at least double that value. Between 2007 and 2011, values for MS4-4b and c remained similarly elevated. Nitrogen concentrations at both sampling points rose even higher above historical means during the 2012/2013 sampling period. A TN reading of 8.6 mg/L was recorded during one MS4-4c dry weather event. The 2013 Brown and Caldwell report suggests that animal waste is a likely source of nitrogen during baseflow events. The increase during wet events is more likely to be linked to the abundance of landscaped area where fertilizers are used.

**Metals**

Metals from municipal or industrial sources can reach streams via stormwater runoff and are readily absorbed by organic matter and sediment particles. They can be released and become harmful to aquatic life under low or high pH conditions. Georgia EPD specifies two classifications for elevated metal concentrations in waterways: acute and chronic. “The acute limitation may not be exceeded in a 1-day, 10-year minimum flow (1Q10), or higher stream flow, while the chronic limitation applies to the 7-day, 10-year minimum flow (7Q10), or higher stream flow.”

From 2006 to 2008, arsenic, copper, lead, and zinc (all of which can be harmful in high concentrations) were sampled during eight events – half wet and half dry. Arsenic was not
detected in significant quantities. MS4-4a and b were the only two sampling locations in which copper was not detected above the State’s acute or chronic maximum allowable criteria. Likewise, the sampling locations associated with Lake Herrick were the only two in which excessive amounts of lead and zinc were never detected.\textsuperscript{109,110} One MS4-4b sample in 2009 did exceed the State’s chronic criteria for lead, but was still below the acute value. A MS4-4c sample in 2010 exceeded both acute and chronic criteria for zinc. Results from all other samples were below both acute and chronic State maximum allowable limits.\textsuperscript{111} Copper at MS4-4b exceeded the state’s criteria during a sampling event in 2013.\textsuperscript{112}

III. C. Water Quality Monitoring Summary

The high variability observed in stage relationships between MS4-4b and c and between wet and dry sampling events for both locations may indicate that there are not enough samples to identify a definite pattern. The 2010 Brown and Caldwell report identifies bacteria as a main parameter of concern; during that monitoring period, Lake Herrick’s outflow only had one elevated bacteria sample but half of the samples from the Parvo Pond outflow exceeded bacterial standards.\textsuperscript{113} Over the course of the MS4 monitoring program, bacteria levels have exhibited a slight downward trend in Lake Herrick and rarely exceed the State’s criteria. Bacteria is elevated and levels are increasing at Parvo Pond. Based on data from the MS4 monitoring program and sporadic measurements from previous years, dissolved oxygen levels have fluctuated year-to-year. It occasionally drops below acceptable limits, most notably during the 2009/2010 monitoring period. Parvo Pond consistently has lower dissolved oxygen levels than Lake Herrick. pH has become a constituent of concern in recent years, especially at Parvo Pond, dipping below acceptable limits in 2009, 2010, and 2011. Average turbidity levels have remained fairly constant in Lake Herrick over time, excluding a significantly heightened average during the 2007/2008 monitoring period. Average turbidity in Parvo Pond has increased greatly over the course of the MS4 monitoring program. Parvo Pond and its corresponding tributary stream is a clear vector for elevated quantities of sediment flowing into Lake Herrick. Nitrogen and phosphorous have also both been on the rise in recent years; the 2010 Brown and Caldwell report identifies both nutrient types as main parameters of concern, and in 2011 and 2012 each parameter had one particularly elevated reading at Parvo Pond during separate dry events. Average increases in both parameters at Parvo Pond are mirrored by less severe increases at Lake Herrick, perhaps influenced by inputs from the pond. Metals have generally not been present in notable amounts, although excessive levels of copper, lead, and zinc have been detected in recent years. Conductivity, temperature, and VOCs have remained fairly constant over time and are not constituents of concern.

Parvo Pond exhibits more undesirable levels of almost every parameter than Lake Herrick, and significant changes in numerous parameters indicate a relatively rapid decline in water quality since 2010. The pond conveys polluted water to Lake Herrick, the impact of which becomes diluted at least to some extent by the lake’s larger volume. Improving the water quality of Parvo Pond may be one way to address the larger problem of Lake Herrick. However, the
pond may also have a benefit; it may be acting as a buffer, protecting Lake Herrick from receiving more direct impacts in full force.

Brown and Caldwell noted that the earthen dam at the Parvo Pond outfall is leaking in places and the wooden supports for the outfall pipe had collapsed. The pond has no outlet structure, and flows discharge through two pipes, forming two separate streams below the dam. The streams have very little baseflow and support high levels of iron-reducing bacteria. They also noted the severely eroded state of the gullies which contribute water and sediment to Lake Herrick. The 2011 Brown and Caldwell report suggests that the water quality could be improved by installing an outlet control structure. In 2013, Brown and Caldwell noted a significant increase in bacterial concentration at this location and cited the nearby dog park as a likely contributor.

Increases in a single parameter, such as sediment, may have the ability to negatively affect many of the other monitoring parameters. Heightened sedimentation could result in more inputs of nutrients, metals, and organic matter. Decomposition of that organic matter could drive down dissolved oxygen levels, resulting in the release of even more nutrients and metals from their chemical bonds. These changes might be reflected by changes in pH and conductivity. More rigorous analysis of existing monitoring data would be needed to develop a strong theory regarding the nature of the pollution present in the Lake Herrick watershed. Average trends indicate that water quality may be decreasing for both Lake Herrick and Parvo Pond. More frequent monitoring would provide a clearer picture of water quality trends over time, as it could help to prevent the high variability that results when averages are skewed by single outlier values.

IV. Summary of Problems for Lake Herrick

Former Oconee Forest Park Manager Dan Williams has identified sedimentation as the most significant water quality problem in the lake. Sediment inputs primarily enter the lake from its two tributaries. The sediment carries bacteria and nutrients, causes the water to be “unacceptably cloudy,” and is slowly filling the lake. One primary source of sedimentation is the area around Parvo Pond, which contains large amounts of highly erodible fill dirt. The pond itself is loaded with sediment. Historically it had more volume, but much of the south end of the pond has been filled with sediment which washed in through one of the 30-inch culverts under the loop and formed a delta. The culverts which bring runoff from the bypass and the UGA Transit Center contribute significant sediment loads. A high amount of sediment in overland flows is also noted, some of which can be attributed to trail erosion caused by mountain bikes. A considerable amount of unconsolidated sediment rests in Lake Herrick near the inlets of both streams and in its deepest area near the dam. Decreasing lake depth is a testament to this. The sediment brings in organic material which, when combined with hot dry weather and limited water circulation, contributes to toxic blue-green algae blooms.

Bacterial contamination is also an issue; sanitary concerns related to the flock of geese which inhabits the beach caused a significant maintenance problem and ultimately contributed to the closure of Lake Herrick’s swimming facilities. Wildlife probably cause most of the bacterial
contamination, but waste from dogs, especially near the off-leash area, may also factor in significantly. There is no evidence of bacteria inputs from leaking sewage infrastructure. Although monitoring results usually show bacteria in the lake to be in compliance with Georgia Environmental Protection standards for open water swimming areas, concern about bacterial contamination is often expressed amongst members of the University community at large. The general public perception of the lake seems to overestimate the degree to which the water is contaminated. The lake receives bacterial inputs from overland runoff, the two tributary streams, and fecal inputs from wildlife at the beach.

Conflicting management schemes have also been problematic. The School of Forestry wanted to manage the lake to provide good fishing, and the Recreational Sports Department wanted good swimming. Management for fishing involves fertilizing the lake to stimulate diatomaceous algae and zooplankton. Much of the excess nutrients from fertilization accumulate in the lake sediments; when they are stirred up, they stimulate algal and fungal blooms which interfere with swimming and potentially with fishing as well.

One final problem is the heavy impact on the landscape by the huge numbers of people who utilize the Lake Herrick watershed for recreational purposes. Oconee Forest Park alone reportedly receives over 50,000 visitors annually. With these visitors come park rules violations. People do not observe leash rules or clean up after their pets, they take more fish than catch limits allow for, and ride bikes on trails which are marked off-limits. All of these violations are inevitable to some degree, but many can be reduced by more effective signage, enforcement, and site design.

V. Lakes and Rivers at Other Southeastern Universities

In an attempt to survey the larger institutions of the southeastern U.S. that were relatively close to the University of Georgia geographically, we contacted major universities to find if the school officially sponsored a large river, lake, or pond on campus for student recreational use, and if so, how was the maintenance of the body of water and its facilities was financed. We found that, similar to the University of Georgia and its dealings with Lake Herrick, the maintenance of such a body of water and its facilities is often spread throughout various departments (i.e. Recreational Sports Department, the Facilities or Grounds Crew Department, the Wildlife and Fishery, Forestry, or Ecology Department). As a result, every effort was made to contact each possible department if necessary to cross-reference whether a body of water was maintained for the campus and if so, by whom.

For the most part, many schools, such as the University of Alabama, Vanderbilt University, University of Kentucky, and the University of South Carolina, did not have a waterway or body of water located on campus that the school officially sponsored in any capacity. Many of the university representatives we contacted expressed a desire to have a lake on campus to further outdoor recreational activities for the students.

Various campuses did, however, have a lake on campus that was utilized by students. Schools maintained the lakes for different purposes and there was a wide variance between schools as far as which department was in charge of caring for the lake and the facilities and
grounds around the lake. For example, Mississippi State’s Chapwick Lake is used for a variety of student activities including a walking trail, fishing, and boating activities and is staffed by the Recreational Sports Department. The maintenance of the lake and the surrounding area however, is the responsibility of the Facilities Department. Further, the lake has benefited from funding from the school’s Kinesiology Department through its Health and Wellness Program. This funding originated from a nearly $600,000 Blue Cross/Blue Shield of Mississippi grant as part of an initiative to promote health and exercise throughout campus and the community. These funds were used to construct the mile-long walking trail around the lake, provide free health screenings, and implement a mass media campaign which promoted healthy habits and choices at the university and in the surrounding local community, among other purposes. Mississippi State also has plans to construct a large island in the middle of the lake that will double as another attraction for students as well as a large filtration system. These plans are in the infant stages however, and the final costs associated with this construction and the source of funding for this project have yet to identified.

Auburn University has a smaller pond located in its Agricultural Heritage Park. The Facilities Department maintains the pond as a part of the park as a whole. However, unlike Chapwick Lake, Auburn does not staff the pond with any personnel from any department. It is the sole responsibility of the Facilities Department.

Clemson University utilizes facilities located on Lake Hartwell. Students use Lake Hartwell for canoeing, kayaking, and rowing. Club teams such as the sailing, ski, and fishing clubs also use it extensively. Banks of the lake are used for other activities such as a tailgating during football season. The area around the lake and the facilities that Clemson uses is maintained by finances secured through the Recreational Department and student fees.

The University of Florida has the one of the most successful examples of a lake utilized for student use in the form of Lake Wauburg. Although the land was deeded to the University for student use, the University never agreed to pay for the upkeep of the lake. As a result, the lake was closed. In an effort to revive the lake as an amenity for students, the Student Union took on the responsibility of maintaining and improving the lake and the facilities on the lake. Through fundraising activities and donations, the Student Union finances the upkeep of Lake Wauburg while the Recreational Department staffs it. Lake Wauburg is used for boating, disc golf, sailing, water skiing, wake boarding, fishing, an extensive outdoor challenge course and is home to a climbing wall. Lake Wauburg has over 65,000 visitors a year and is one of the largest outdoor recreation centers in the entire southeast and rivals state sponsored centers.

There are not many examples of large schools in the southeast that officially maintain a large body of water for student use, however many universities have a strong desire for such a recreational amenity. The schools that do have such a lake, have varying policies on the upkeep, and financing of that upkeep, of the lake. There is no best practices standard that can be found. Each school has the same problem: various departments handling different aspects of the lake with no centralized body overseeing the lake in an efficient manner. The University of Florida
provides an outstanding example of what can happen with an organized approach to the management of a body water.

Contacts:

- **Auburn University**
  - Director Rec Sports Jennifer Jarvis (334) 844-4716
  - Facilities Department (334) 844-4810

- **Clemson**
  - Assistant Director Club Sports Stacey Pettigrew (864) 656-5492
  - Graduate Assistant Outdoor Rec (864) 656-0892
  - Director of Landscape Service Adrienne Gerus (864) 656-4229

- **Mississippi State University**
  - Director Recreational Sports Laura Walling (662) 325-2179
  - Blue Cross Blue Shield of Mississippi Director Sheila Grogan (601) 932-3704
  - Department of Kinesiology (662) 325-296

- **University of Florida**
  - Lake Wauburg (352) 466-4112
  - Rec Sports Administration Office (352) 846-1081

**VI. UGA Student Survey**

We conducted a short survey to determine what current UGA students know and think about Lake Herrick, gauge their interest in lake-based activities, and ask their opinions about whether the lake should be reopened in the future.

**VI. A. Overview of Survey: recruitment, sampling, and data collection methods**

We conducted the survey between 10:30am and 1:30pm on Tuesday April 8 and Thursday April 10, 2014 in the Tate Plaza. Both days were sunny and pleasant, which was ideal given that the survey was conducted outside. There was considerably more foot traffic on the first day of the survey, perhaps drawn by the large agricultural demonstration taking place in the same area with live animals (e.g. llamas, sheep, chickens, cows) and country music.

Students were recruited to participate in the survey through a simple phrase to draw their interest and get them to stop, usually something like, “Wanna answer a few questions for a chance to win prizes?” or “Do you have time for a quick survey?” We made every effort to ask a diversity of people to participate, but avoided people who were obviously uninterested (e.g. walking very fast or veering away. If people asked what the survey was about, we said simply, “It’s about recreation at UGA.” Both the recruitment script and survey description were kept intentionally vague and neutral, so as not to oversample people with particularly strong feelings (positive or negative) about Lake Herrick or environmental conservation and restoration more generally. However, if people asked at the end of the survey what we were doing, we would explain that this was part of a larger group project in an Environmental Law class to look into restoring Lake Herrick, and show them a simple 1-page information sheet about the lake.
To encourage a higher number of people to participate, we solicited gift certificates from local businesses (UGA Bookstore and Ben & Jerry's). Participants were initially told that they could win prizes in the recruitment script, and when they finished the survey we explained that we would hold a drawing to give away these gift certificates the following week. These incentives increased participation and drew in a more diverse group of students.

VI. B. Survey Findings

A total of 77 students were surveyed (see Table 3). The majority of students were undergraduates, roughly split evenly amongst class standing. Only 4% of those surveyed were graduate students. They represented a total of 46 majors and included both men and women.

Table 3: Composition of Students Surveyed

<table>
<thead>
<tr>
<th>Level at UGA</th>
<th>Percent of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>29</td>
</tr>
<tr>
<td>Sophomore</td>
<td>23</td>
</tr>
<tr>
<td>Junior</td>
<td>22</td>
</tr>
<tr>
<td>Senior</td>
<td>21</td>
</tr>
<tr>
<td>Graduate</td>
<td>4</td>
</tr>
</tbody>
</table>

Students used a variety of both on- and off-campus recreational facilities (see Table 4). The Ramsey Center was used most frequently, with a majority of students surveyed (58%) using this facility at least once a month. While used less often, the second most used facility was the Intramural Fields, with 18% of students using these once a month and an additional 14% using them once a semester. Most other facilities were used significantly less often, with a majority of students saying that they never used Legion Pool (79%), the Georgia Outdoor Recreation Program trips or classes (87%), Oconee Forest Park (69%), or off-campus gyms or classes (70%).

Table 4: Student Use of Other Recreational Activities:

<table>
<thead>
<tr>
<th>Facility</th>
<th>% used at least once a month</th>
<th>% used at least once a semester</th>
<th>% used rarely</th>
<th>% never used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramsey</td>
<td>58</td>
<td>14</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>Legion Pool</td>
<td>0</td>
<td>1</td>
<td>19</td>
<td>79</td>
</tr>
<tr>
<td>Intramural Fields</td>
<td>18</td>
<td>14</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>GORP</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>87</td>
</tr>
<tr>
<td>Oconee Forest Park</td>
<td>5</td>
<td>10</td>
<td>16</td>
<td>69</td>
</tr>
<tr>
<td>Off-campus</td>
<td>10</td>
<td>8</td>
<td>12</td>
<td>70</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>92</td>
</tr>
</tbody>
</table>
Other recreational facilities that students mentioned included Sandy Creek Nature Center, dormitory facilities, club sports, and the Botanical Gardens.

A majority of the students surveyed had heard of Lake Herrick before, while 40% of students had never heard of the lake (see Table 5). Most students who had already heard about Lake Herrick had also visited the lake (40%) while fewer people had only heard the name without knowing where it was (8%) or never having been there despite knowing where it was (12%).

Table 5: Knowledge of Lake Herrick amongst Students

<table>
<thead>
<tr>
<th>Knowledge of Lake Herrick before Survey</th>
<th>Percent of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Had never heard of lake</td>
<td>40</td>
</tr>
<tr>
<td>Heard of lake but did not know where it was</td>
<td>8</td>
</tr>
<tr>
<td>Heard of lake, knew where it was, had never been there</td>
<td>12</td>
</tr>
<tr>
<td>Heard of lake and had been there before the survey</td>
<td>40</td>
</tr>
</tbody>
</table>

Of the students who had already heard about Lake Herrick, their impressions or experiences of the lake can be divided into four general different categories (see Table 6).

First, some students just described the different activities that they had done at the lake, of which biology laboratory experiences were the most common followed by walking or running on the trails nearby.

Second, students offered either negative or positive assessments of the current state of Lake Herrick. Negative impressions of the lake focused on the perception that the water was not clean and that the resource was not well maintained. Positive impressions of the lake focused on its pleasing aesthetics. Interestingly, slightly more students wrote positive descriptions of the lake. This might be due to the fact that some people who had only heard of the lake without ever visiting themselves tended to write positively of the lake, or the fact that some students’ impressions seemed generalized to the region as a whole encompassing not just Lake Herrick but also the surrounding land and trails.

Finally, students also expressed regret or disappointment with the fact that the lake was not in a condition that permitted certain activities (e.g. swimming, fishing, boating) and a desire that the lake be restored to more optimal conditions.

Table 6: Four Categories of Student Impressions or Experiences of Lake Herrick

<table>
<thead>
<tr>
<th>1) Types of Experiences</th>
<th>2) Negative Impressions</th>
<th>3) Positive Impressions</th>
<th>4) Desire for restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running on trails, mycology class in forest.</td>
<td>… it looks pretty gross.</td>
<td>Everything is very pretty....</td>
<td>It’s a shame it is gross, could be beautiful.</td>
</tr>
<tr>
<td>I’ve visited, ran there, and let my dog jump in …</td>
<td>go in the lake.</td>
<td>… trails aren’t kept up.</td>
<td>… It seems really beautiful and I have friends who love it, I’ve just never been.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>I went there during biology lab and did observations for study purposes.</td>
<td>… troubled by run-off and a bit of pollution.</td>
<td>Peaceful.</td>
<td>Beautiful lake…</td>
</tr>
<tr>
<td>I went there for my biology lab and sometimes go jogging.</td>
<td>I know it was closed because of pollution.</td>
<td>Beautiful lake…</td>
<td>… the docks are nice</td>
</tr>
<tr>
<td>I walked around it and saw some cool ducks.</td>
<td>… A little trashed.</td>
<td>I think Lake Herrick is beautiful!</td>
<td>I think it’s kind of unfortunate that it’s not inviting and many people don’t know that it’s there.</td>
</tr>
<tr>
<td>I’ve eaten at the picnic tables before.</td>
<td>It’s ok, pretty dirty.</td>
<td>Fun to visit, the trails through Intramural Fields are fun.</td>
<td>I would like for it to be open so I can enjoy the scenery.</td>
</tr>
<tr>
<td>Biology class required a trip … Also PE walking class walks around the trails.</td>
<td>It was pretty, but the water doesn’t look good for swimming.</td>
<td>The lake is nice.</td>
<td>I really wish that the ecological environment could be improved.</td>
</tr>
<tr>
<td>I went for a class.</td>
<td>Lake seems unclean.</td>
<td>It was pleasant.</td>
<td>… I wish was clean enough for recreation.</td>
</tr>
<tr>
<td>I run there a good bit and enjoy the scenery.</td>
<td>It has a lot of potential but the water is contaminated.</td>
<td>Clean, pretty.</td>
<td>… it is a shame that it is not open for swimming and fishing.</td>
</tr>
<tr>
<td>I took samples in biology lab.</td>
<td>I’m not impressed. But I guess it’s better than nothing. It doesn’t look clean or natural.</td>
<td>I think it’s pretty …</td>
<td>It was okay but it needs to be taken care of a little more.</td>
</tr>
<tr>
<td>I’ve just heard it’s there and walked around it.</td>
<td>The water was very cloudy and full of aquatic animals.</td>
<td>I have never been, but I heard it was a nice lake.</td>
<td>I would like to be able to use it for fishing and kayaking.</td>
</tr>
<tr>
<td>I’ve been for</td>
<td></td>
<td>It’s beautiful especially the sand and birds, but the waterbody could be bigger.</td>
<td>… [it] would be nice to have for recreational purposes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It was cool.</td>
<td>Me and my boyfriend walked the trail around and</td>
</tr>
</tbody>
</table>
Students were asked to select which of six potential activities they would be likely to use Lake Herrick for if this resource were to be restored in the future (see Table 7). The list of potential activities was derived from the actual activities for which Lake Herrick was used in the past before its closure, as well as the types of activities that on-campus water bodies are used for in other schools. The majority of students surveyed expressed interest in using a restored lake for outdoor social events and non-motorized boating. Around half of students expressed interest in using the lake for swimming and beach volleyball. Fewer students expressed interest in using the lake for fishing and physical education classes.

Table 7: Student Interest in potential Lake Herrick activities

<table>
<thead>
<tr>
<th>Potential Activity</th>
<th>Percent of students likely to use Lake Herrick for activity if restored</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor social events (BBQ, picnic, etc.)</td>
<td>69</td>
</tr>
<tr>
<td>Boating (kayak, canoe, paddle, sail, etc.)</td>
<td>68</td>
</tr>
<tr>
<td>Swimming</td>
<td>52</td>
</tr>
<tr>
<td>Beach Volleyball</td>
<td>48</td>
</tr>
<tr>
<td>Fishing</td>
<td>44</td>
</tr>
<tr>
<td>Physical Education class</td>
<td>32</td>
</tr>
</tbody>
</table>

VI. C. Recommendations from the UGA Student Survey

The purpose of this survey was to gauge student knowledge about Lake Herrick and their interest in activities if this on-campus water resource be restored in the future. The survey results clearly show that many students are aware of Lake Herrick and often have visited it themselves as part of natural science classes or to use the nearby walking trails. Students expressed both positive and negative impressions of the lake. More importantly for this project, many students expressed a desire for the lake to be restored to a cleaner state that would allow for water-based
activities. Based on these findings, it seems clear that there is sufficient student interest in cleaning up and using the lake to merit restoration efforts.

One recommendation based on the survey findings would be to accompany any restoration efforts with significant outreach and education efforts. While the lake has been closed for swimming, boating, and fishing for nearly a decade, it continues to be used by many biology labs about water quality and microbes. Also, students who use the nearby walking trails or intramural fields have seen signs posted that the lake is closed. Both of these factors have given students the impression that the lake waters are contaminated and polluted. If the lake is restored in the future, it would take more than just new signs to make people feel comfortable using the lake for swimming, boating, or fishing. A second recommendation based on the survey findings would be to integrate Lake Herrick recreational activities with the Ramsey Center, as a great majority of students used this resource at least monthly.

VII. Local Outreach Opportunities for Lake Herrick

VII. A. UGA Office of Sustainability

The University of Georgia’s Office of Sustainability was established in 2010. Part of the work of the office is to create a Sustainability Plan for the university to help organize campus initiatives and establish areas of concerted effort. Part of the 2010-2015 plan includes 5 areas of focus: Teaching, Research, Public Service and Outreach, Student Activities, and Operations.118 Public Service and Outreach states that the University will extend “resources in the form of professional knowledge and expertise to help communities [emphasis added] improve their quality of life.”119 The description continues by describing how the office will support communities. The Office will “engage with UGA service-learning programs [emphasis added] to combine active, experiential and inquiry-based learning with real world problem solving on campus and in the broader community.”120 Section VII examines the support the university provides to Athens-Clarke County and the local K-12 educational community, as well as offering suggestions as to how the university can increase opportunities to support education for sustainability.

VII. B. Athens Water Festival

The Athens Water Festival was first held in 2003 at Sandy Creek Park. This festival was started as a way to celebrate and educate members of the Athens community the significance of water in their lives. Part of the rationale for creating the Athens Water Festival was to celebrate the ongoing Oconee Greenway Project which had recently completed a bridge over the river.121 Stephanie Brown, one of the events organizers, describes the festival as “a community celebration of the environment. We want to educate people about what they can do to protect the water. It's very educational, but it's also fun.”122 The first festival contained games, a bike parade, live music, but is also included many displays to help educate visitors.

The Athens Water Festival at Sandy Creek Park continues to be an important part of the community today. During the summer of 2013, Athens was still recovering from an extended
drought. While being interviewed about the continued watering restrictions in place for Athens Clarke County, Mayor Denson was also asked about educating the public about water conservation. Her response included the Athens Water Festival as part of that educational effort. The Water Festival is promoted throughout the community in many ways. One such promotion under the headline “Different Date Night” touts the family friendly nature of the festival. The Water Festival is even used as an event to promote the city of Athens to tourists, and a brief description of the event is included in tourism materials of the Athens Convention and Visitors Bureau.

Parts of the university community have been involved with the Water Festival for some time now as media coverage of the event shows. Different colleges within the university have been described as bringing interactive displays and animals to the event to help attract visitors. Few media articles directly mention the UGA college or department by name. The Warnell School of Forestry and Natural Resources is listed as being a part of the festival in 2011 and 2013. The Marine Extension Service is listed as participating in 2013. Also mentioned is the Department of Crop and Soil Science in 2011. While other years appear to reference activities which may have been sponsored by the university, these were the only explicit references to university participation.

While the university is clearly involved in the Athens Water Festival, this participation is not documented or promoted online by the university itself. No mention of the Athens Water Festival can be found in various university departmental websites, although there are occasional descriptions of projects and water festivals for other parts of the state. The Office of Sustainability’s own website has no mention of this community event. This lack of information on these websites presents an interesting dilemma. The university’s involvement with the Athens Water Festival may be well documented by media outlets, but it is unclear of the level of participation by UGA departments lives up to the stated objective of “learning with real world problem solving on campus and in the broader community.”

VII. B. Lake Herrick Service Learning and Hosting Opportunities for the Athens Water Festival

The Athens Water Festival provides a forum for the University of Georgia to engage with the local community to share the significance of water in all aspects of life. The efforts to restore Lake Herrick provide a “real world problem” that members of the university community are working to solve. As the Intramural Fields, Lake Herrick, and Oconee Forest are public recreation spaces, the need to connect the university community as well as the larger Athens area community to this resource have been established by the survey data discussed earlier. Fortunately, the university has already established a tradition of working at the festival to provide learning opportunities for the public, although this activity should be better promoted online. Now that the educational connection is in place, the university could do more to increase awareness of festival and the service learning opportunities that it provides to students, faculty, and staff.
Service learning opportunities should be promoted online so this information is more accessible to students who may be interested in taking part. One suggestion for the Office of Sustainability is to assist by including the Athens Water Festival on their own website in the Annual Events page, the Sustainable Events page, or the online calendar. If the Office of Sustainability is to continue to promote service learning in the community, then seeking out new events is essential. However, access to these events should be promoted online where a growing number of students are spending their time. The Office of Sustainability should encourage the promotion of service events, as well as the history of service learning the University has created while continuing to look for more opportunities to serve.

As the health of Lake Herrick improves and the body of water is approved for recreation, the myriad of UGA departments along with the Office of Sustainability may be able to work with the ACC government to allow the hosting of the Athens Water Festival to take place along Lake Herrick. Having the festival on campus would increase the proximity to students living on campus and the likelihood that more students could serve as a host and or environmental educator for the festival. The re-opening of Lake Herrick for recreation gives the greater community a chance to promote the understanding and respect required to maintain water resources.

VIII. Proposed Monitoring Plan for Lake Herrick

As managing entity of Lake Herrick, Warnell School of Forestry (Warnell) is responsible for the decision to close the lake, citing high levels of fecal coliform and algal blooms. However, it is our belief that Lake Herrick is not actually as polluted as it once was and is currently thought to be. Based on ongoing monitoring data, we believe that the pollution in the area is largely relegated to the tributaries, particularly the one that flows to the lake from the “Parvo Pond.” This idea has not yet been verified with a thorough examination of the water quality and pollution sources of Lake Herrick, and thus no methods have been employed to control the pollution flowing from that tributary.

Lake Herrick is monitored quarterly at three locations for a subset of water quality criteria by external consulting firm Brown & Caldwell. However, to examine the possibility of re-opening the lake to swimming and other contact activities with the water, a more rigorous sampling regimen is required. The remainder of this Section VIII lays out a sampling plan for the swimming area in accordance with the Georgia Department of Natural Resources Parks, Recreation, and Historic Sites Division (PRHSD) “operated lake and swimming areas monitoring plan” as well as a budget for the sampling.

Extensive water quality monitoring across the entire lake is a possible strategy and perhaps one to address in the future to allow fishing and boating to coexist effectively. There are several well-documented approaches for this characterization process. While this proposal lays out some recommended monitoring guidelines for the whole lake, as recommended by previous practicum students and Renee Perro, the first focus is to address pollution at the beach area, as swimming could occur immediately if the lake were to reopen; boating and
recreation are reliant on gear and would require a longer timespan to get started. This swimming-oriented approach can happen quickly, easily, relatively cheaply, and could serve as a stepping stone to reinvolve the campus and surrounding community with the Lake Herrick watershed and its amenities.

**VIII.A. Monitoring the Beach**

The following monitoring plan follows guidelines set out by the PRHSD.\(^{137}\) We recommend sampling locations, frequency, and procedures to allow this monitoring to begin as soon as May 2014.

**VIII.A.1. Sampling Locations**

Sampling along the beach should occur at the most heavily used portions. Because Lake Herrick has not been open to swimming for the past decade and because we want to characterize the bacterial pollution along it to the greatest extent possible, we propose sampling points at the middle of the beach and at each end of the beach.

Additional sampling points should be placed between the beach and any suspected sources of pollutants.\(^{138}\) Suspected sources of pollutants at Lake Herrick include the two tributaries and nearby housing developments, intramural fields, and roads, requiring four additional monitoring points. A map of all the proposed sampling points is shown in Figure 2.

![Figure 2. Map of 7 proposed monitoring locations at Lake Herrick](image-url)
VIII.A.2. Sampling Frequency

According to the PRHSD swimming area standards, the minimum for watershed monitoring of fecal coliform is 4 samples within 30 days, with no two samples taken within 24 hours of each other. The geometric mean of these samples should contain fewer than 200 colony-forming units (cfu) per 100 milliliters of water. In the event that samples contain higher levels of bacteria than this maximum, additional testing should be conducted. More frequently recommended, and in-line with EPA testing for water bodies covered by the Clean Water Act, is five samples within a five-week period\(^\text{139}\). The geometric mean for these samples should be less than 126 cfu, with no single sample surpassing 235 cfu. Combining these 2 sets of constraints, we follow the Georgia PRHSD guidelines with the EPA’s more frequent testing, averaging one sample per week.

VIII.A.3. Sampling Dates

The swimming season for Lake Herrick is approximately May through September. As such, these are the dates that are most relevant for monitoring the swimming area for bacteria levels. Generally, annual testing of an established swimming lake is conducted for the five weeks prior to Memorial Day weekend. However, as Lake Herrick has not been used as a swimming lake in nearly a decade, extensive testing should be undertaken throughout the entire swimming season. Monitoring should begin Memorial Day weekend and complete on Labor Day weekend, with one sample taken weekly at each specified sampling location. The recommended dates for 2014, all on Mondays, are listed in Table 8. (Mondays were chosen because that is the day of the two holidays that mark the beginning and end of the swimming season; any consistent day of the week would work equally well.)

<table>
<thead>
<tr>
<th>Month</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>26 (Memorial Day)</td>
</tr>
<tr>
<td>June</td>
<td>2, 9, 16, 23, 30</td>
</tr>
<tr>
<td>July</td>
<td>7, 14, 21, 28</td>
</tr>
<tr>
<td>August</td>
<td>4, 11, 18, 25</td>
</tr>
<tr>
<td>September</td>
<td>1 (Labor Day)</td>
</tr>
</tbody>
</table>

Table 8. Recommended sampling dates

VIII.B. Sampling Procedure

Samples are taken at a depth of one foot underwater near the suggested locations and where the total water depth is approximately three feet. Only sample bottles provided by the testing laboratory should be used, as they contain a substance important to the analysis. Once the sample bottle is filled with water, it should be capped, labeled with the date, time, and sample location, and placed in a cooler filled with ice. Samples should be collected in the morning and transported to the testing laboratory within two hours of being collected or before noon, whichever is sooner. The person conducting the sampling should also be prepared to fill out a
chart similar to the one shown below in Table 9, which includes weather conditions from the past 72 hours and observations of waterfowl and wildlife.

<table>
<thead>
<tr>
<th>Sample ID #</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Point Location</td>
<td></td>
</tr>
<tr>
<td>Collector Name</td>
<td></td>
</tr>
<tr>
<td>Date Collected</td>
<td></td>
</tr>
<tr>
<td>Time Collected</td>
<td></td>
</tr>
<tr>
<td>Weather Today</td>
<td></td>
</tr>
<tr>
<td>Weather Yesterday</td>
<td></td>
</tr>
<tr>
<td>Weather 2 Days Ago</td>
<td></td>
</tr>
<tr>
<td>Presence of Waterfowl</td>
<td></td>
</tr>
<tr>
<td>Water Color and Appearance</td>
<td></td>
</tr>
<tr>
<td>Other Notes</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Sampling chart

**VIII.C. Budget**

Grab samples of lake water will be analyzed by the Agricultural & Environmental Services Laboratory using the Membrane Filtration Method\(^{140}\). The total for an entire summer’s worth of testing is $3,465. Table 10 shows the breakdown of this cost. Special pathogen-specific sampling containers are provided by AESL.

<table>
<thead>
<tr>
<th>Fecal coliform sample, tested by AESL</th>
<th>$33 per sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sampling locations</td>
<td>7</td>
</tr>
<tr>
<td>Number of weeks, with 1 sample each week</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$3,465</strong></td>
</tr>
</tbody>
</table>

Table 10. Fecal Coliform Monitoring Budget

**VIII.D. Whole-Lake Monitoring**

A more thorough characterization of the entire lake requires more tests, equipment, and effort. Based on established practices, the lake should be monitored at multiple depths in multiple locations across the lake to give a full picture of its health. Important properties to monitor include temperature, turbidity, dissolved oxygen, nutrients, pH, fecal coliform, and chlorophyll a, as well as a visual assessment of the nearby plant and animal communities. In-depth procedures for measuring these water quality indicators are listed in the Georgia Environmental Protection Division’s Standard Operating Procedures,\(^{141}\) and we provide a very brief summary of the key points here.

Lake profiles are established through monthly monitoring, utilizing electronic probes for depth, dissolved oxygen, temperature, pH, and conductivity. These parameters should be measured at a given sampling location for every meter of the lake’s depth, starting just below the surface of the water and going to the very bottom of the lake. Nutrients including nitrogen and
phosphorus should be analyzed as composite samples; a composite consisting of equal volumes of water from each meter below the surface should be compiled for both the water in the photic zone and the water below the photic zone. Fecal coliform should be taken from just below the surface in special bottles. All samples should be kept on ice before they are delivered to a certified laboratory for analysis.

Because such in-depth analysis and testing is required to provide a full profile of the lake, we recommend beginning with monitoring of the swimming area for fecal coliform and convening a working group to establish which parameters of managing the lake are most relevant for its desired uses in the future, such as dissolved oxygen with regards to fish management or phosphorus with regards to algal bloom control.

Before Lake Herrick can be re-opened to activities involving human contact such as swimming and boating, it must be shown to have safe levels of fecal coliform and pathogens. It is crucial that efforts be made to understand the nature and degree of water quality degradation in Lake Herrick so that steps can be taken to restore this campus amenity.

IX. Legal Issues for Re-opening Lake Herrick

IX. A. Introduction

Lake Herrick is a large facility located at the University of Georgia’s intramural sports complex. The lake has been closed in recent years due to water quality concerns, but the Environmental Practicum is investigating methods of revitalizing the lake for public use. If Lake Herrick were to reopen to the public, the University would need to assess its position of potential liability to the people who utilize it for recreation, because obviously a large lake bears with it the risks of injury. Through application of Georgia’s case law and the Georgia Code, UGA should be able to operate a facility like Lake Herrick without an undue burden of liability.

IX. B. Recreational Property Act

Chapter 3 of section 51 of the Georgia Code is also referred to as the Recreational Property Act. It specifically mentions the legislature’s intent to promote the use of public or private land and water facilities for recreation: “The purpose of this article is to encourage owners of land to make land and water areas available to the public for recreational purposes by limiting the owners' liability toward persons entering thereon for recreational purposes.” Ga. Code Ann. § 51-3-20.

The following article goes on to define recreational purposes as “includ[ing], but… not limited to, any of the following or any combination thereof: hunting, fishing, swimming, boating, camping, picnicking, hiking, pleasure driving, nature study, water skiing, winter sports, and viewing or enjoying historical, archaeological, scenic, or scientific sites.” Ga. Code Ann. § 51-3-21. As such, the supposed uses of the lake would fall neatly within this category.

The chapter goes on to describe how a landowner owes no duty to warn users of unsafe conditions, unless the landowner demonstrates willful or malicious failure to warn. Ga. Code Ann. § 51-3-22; Ga. Code Ann. § 51-3-25(1). Willful and malicious failure to warn includes (1)
that the landowner has actual knowledge that the property was being used for recreational purposes; (2) that the landowner has actual knowledge that a condition exists involving unreasonable risk of death or serious bodily harm; (3) that the condition was not apparent to those using the property; and (4) that the landowner chose not to warn users, in disregard of the possible consequences. Constructive knowledge of any of these factors is insufficient to impose a duty. Collins v. City of Summerville, 284 Ga. App. 54, 56, 643 S.E.2d 305, 308 (2007).

XI. C. Access
The users of the facility are neither licensees nor invitees, per OCGA § 51-3-23, and thus liability is generally very limited. However, the whole analysis changes if the University charges admission to the lake facilities. Charge is defined as “the admission price or fee asked in return for invitation or permission to enter or go upon the land.” While merely collecting money for specific related uses (i.e. parking, boat rental, etc.) does not constitute charging admission, a more direct charge for access to the lake may change the analysis to fall outside the scope of the RPA, with a more demanding duty of ordinary care owed to the invitees. Majeske v. Jekyll Island State Park Authority, 1993, 209 Ga.App. 118, 433 S.E.2d 304.

The University need not charge admission in order to operate the lake, though. Funds to support the lake’s activities could come from student fees, as fees collected from all students at the beginning of the semester would not amount to admission costs. The fees would fund student activities generally, and thus not constitute a direct admission to the lake. The Georgia Court of Appeals held in 1993 that although the plaintiff had helped pay for a church softball league via church contributions, this did not count as a direct admission fee for the purposes of RPA analysis. Spivey v. City of Baxley, 210 Ga. App. 772, 774, 437 S.E.2d 623, 626 (1993). Student fees are not a “charge” for use of premises, but rather a charge for participating in student activities.

The University may also be able to limit admission to only students and still be covered by the RPA. The courts have held that there may be cases where the facility may be open only to a “class of the public,” rather than the entire general public. Herring v. Hauck, 118 Ga. App. 623, 624, 165 S.E.2d 198, 199 (1968) The central question to the court’s analysis would be the purpose behind the use of the facility—is the facility for public enjoyment, or is it for commercial benefit? Even some marginal benefit, such as advertising purposes or sales promotions, do not qualify as substantial enough commercial benefits to fall outside of the RPA. Bourn v. Herring, 225 Ga. 67, 68, 166 S.E.2d 89, 92 (1969). Still, opponents may be able to argue that the fact that student fees are directly linked to admission equates the student fees to admission fees. The safest and surest way to stay within the confines of the RPA, though, is to allow the lake to be open to the general public, which would conform to the current policy of allowing the trails and fields surrounding the lake to be used by the general public. Boat rental, intramural sports, or other activities at the lake could still be restricted to students only, but access to the lake itself would be open.

X. Ideas and Solutions
Recreational use of Lake Herrick entails complex management problems. Re-opening the lake for swimming may only be done after careful consideration and planning. However, boating is a fairly low-risk use activity, even with the currently questionable water quality. Canoe, kayak, and sailing classes and clinics were eliminated out of concern for potential accidental exposure to the water. However, it is reasonable to think that, barring a particularly toxic algal bloom, anybody who does happen to fall into the lake will exit the water quickly and suffer no adverse health effects.

Before any programmatic changes are made regarding the permissible uses of the lake, existing water quality data should be analyzed thoroughly. The implementation of a more comprehensive and frequent water quality monitoring program is advisable if stakeholders truly wish to understand and address water quality problems. An important point which warrants further investigation is whether annual algal blooms have continued since 2005.

The water quality problems seem to boil down to pollutant inputs from stormwater runoff and bacterial inputs from wildlife. Stormwater inputs can be addressed by updating old drainage infrastructure with green infrastructure best management practices to encourage filtration and infiltration. The aging pond and lake outlet structures both need overhauls and could be effective locations for state-of-the-art BMP updates. The culverts under the bypass have also been identified as heavy contributors of problematic runoff. One solution which has already been proposed is the installation of stormwater detention basins either in the park, at the loop, or at the Transit Center. This would be costly but might be viewed and funded “as a University Community solution to a University Community problem” - Dan Williams.[49] It is also possible that, because the Department of Transportation installed the culverts when the bypass was constructed, they might be obligated to update their infrastructure.

The wildlife issues mainly have to do with the geese which inhabit the lake. It is likely that as long as the beach remains, the geese will flock to it. Even if the beach were removed the geese would probably remain, although their presence would not be as much of an issue if it was not in conflict with the recreational goals for the lake. The surest way to eradicate the geese is sure to “ruffle some feathers”: kill them. The potential for a negative public reception to this management strategy might be countered by featuring the geese as a dish as part of a public “invasive species roast” at the beach pavilion.

The pond which feeds into Lake Herrick has never had an official name, although at some point people began referring to it informally as Parvo Pond. As was the case with Stinky Creek/Lily Branch, a name change might be in order to signal a change in perception and indicate that people do indeed care about it.

VI. References


[6] Id. See Note 2.


[9] Id.

[10] Id.


[17] Id.


[22] See Note 13.


[25] Id.


[29] Id.

[30] Id.


[37] Note in file from Dan Williams labeled “1996 Addendum.” No other source information specified.
[41] Id.
[49] Id.
[52] Unpublished report from Charles Hancock addressed to Dan Williams, May 21, 1986
[58] Document titled Lake Herrick Data from Sept. 2 to Nov. 11, 2001. No other information given.
[62] Id.
[63] Id. at Note 1.


[69] Brown and Caldwell 2011.  See Note 64.

[70] Brown and Caldwell 2013.  See Note 65.

[71] Id.


[74] Brown and Caldwell 2011.  See Note 64.


[77] Brown and Caldwell 2010.  See Note 63.

[78] Brown and Caldwell 2011.  See Note 64.


[80] Brown and Caldwell 2011.  See Note 64.


[85] Brown and Caldwell 2013.  See Note 64.


[87] Id. at Note 64.


[91] Brown and Caldwell 2011.  See Note 64.


[95] Brown and Caldwell 2011.  See Note 64.


[99] Brown and Caldwell 2011.  See Note 64.


[104] Brown and Caldwell 2011. See Note 64.
[115] Id.
[119] Id.
[120] Id.

[129] ACC 2013. See Note 127.


[131] University of Georgia Office of Sustainability 2010. See Note 118.


[137] See Note 133.


[139] See Note 138.


[141] See Note 134.
Appendix A: Lake Herrick Watershed Map
Appendix B: Historic and Current Aerial Photos
The Lake Herrick Watershed in 1944. The watershed boundary and Parvo Pond subwatershed are delineated in red.
The Lake Herrick Watershed in 1993.
The Lake Herrick Watershed in 2013.
Appendix C: Charts and Tables of Select Water Quality Monitoring Parameters

### Fecal coliform (CFU/100 mL)

<table>
<thead>
<tr>
<th>Monitoring dates</th>
<th>Avg. (Wet)</th>
<th>Avg. (Dry)</th>
<th>Avg. (All)</th>
</tr>
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<tr>
<td>MS4-4b</td>
<td>Feb 18, 2006-Dec 13, 2006</td>
<td>36.67</td>
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<td></td>
<td>Oct 4, 2007-Aug 13, 2008</td>
<td>630</td>
<td>18</td>
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<tr>
<td></td>
<td>May 22, 2009-Jan 21, 2010</td>
<td>143</td>
<td>53</td>
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<td>Sept 23, 2010-Jun 23, 2011</td>
<td>151</td>
<td>32</td>
</tr>
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<td>Sept 27, 2012-May 22, 2013</td>
<td>55</td>
<td>21.6</td>
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<tr>
<td>MS4-4a</td>
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<td>600</td>
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<td>618</td>
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<td>92</td>
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<td>12650</td>
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</table>

#### Average Fecal Coliform

![Graph showing average fecal coliform levels](attachment:image.png)

### Dissolved Oxygen (mg/L)

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<th>Avg. (Wet)</th>
<th>Avg. (Dry)</th>
<th>Avg. (All)</th>
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<td>6.69</td>
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<td>4.50</td>
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<td>Sept 23, 2010-Jun 23, 2011</td>
<td>5.02</td>
<td>7.38</td>
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<td></td>
<td>Sept 27, 2012-May 22, 2013</td>
<td>6.42</td>
<td>6.30</td>
</tr>
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### Turbidity (NTU)

<table>
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<th>Monitoring dates</th>
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<th>Avg. (Dry)</th>
<th>Avg. (All)</th>
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<tr>
<td><strong>MS4-4b</strong></td>
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<td></td>
</tr>
<tr>
<td>Feb 18, 2006 - Dec 13, 2006</td>
<td>56.6</td>
<td>7.6</td>
<td>23.9</td>
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<td>May 22, 2009 - Jan 21, 2010</td>
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<td></td>
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<td>Feb 18, 2006 - Dec 13, 2006</td>
<td>51.8</td>
<td>7.6</td>
<td>23.9</td>
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<tr>
<td>May 22, 2009 - Jan 21, 2010</td>
<td>57.35</td>
<td>84.3</td>
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<td>Sept 23, 2010 - Jun 23, 2011</td>
<td>265.13</td>
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<td>161.81</td>
</tr>
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<td>Sept 27, 2012 - May 22, 2013</td>
<td>135.50</td>
<td>141.45</td>
<td>139.47</td>
</tr>
</tbody>
</table>

### Average Turbidity

![Average Turbidity Graph](image)

- **Blue Line**: Lake Herrick
- **Red Line**: Parvo Pond

**X-axis**: Dates
- Feb 18, 2006 - Dec 13, 2006
- May 22, 2009 - Jan 21, 2010
- Sept 27, 2012 - May 22, 2013

**Y-axis**: NTU
- 0 to 300
### Total Suspended Solids (mg/L)

<table>
<thead>
<tr>
<th>Monitoring dates</th>
<th>Avg. (Wet)</th>
<th>Avg. (Dry)</th>
<th>Avg. (All)</th>
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<tr>
<td><strong>MS4-4b</strong></td>
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<tr>
<td>Feb 18, 2006 - Dec 13, 2006</td>
<td>7</td>
<td>8</td>
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<td>5</td>
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<td>Sept 23, 2010 - Jun 23, 2011</td>
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<td>May 22, 2009 - Jan 21, 2010</td>
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### Total Suspended Solids

![Total Suspended Solids Chart](chart.jpg)
### Total Phosphorous (mg/L)

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<td>0.037</td>
<td>0.051</td>
</tr>
<tr>
<td>Sept 23, 2010 - Jun 23, 2011</td>
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<td>0.331</td>
<td>0.213</td>
</tr>
</tbody>
</table>
| Sept 27, 2012 - May 22, 2013 | 0.212      | 0.865      | 0.65       

**Diagram:**
- **Lake Herrick**
- **Parvo Pond**
- **EPA Criteria**
- **EPO Criteria**

*Graph showing total phosphorous levels over time.*
<table>
<thead>
<tr>
<th>Monitoring dates</th>
<th>Avg. (Wet)</th>
<th>Avg. (Dry)</th>
<th>Avg. (All)</th>
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